X-Ray Studies of Wetting At The Free Surface of Liquid GaBi

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Beamline(s): **X22B**

Introduction: It is only recently that x-ray reflectivity measurements of the binary liquid Ga-Bi alloy have revealed the microscopic structure of the free surface above and below the monotectic temperature T_{mono} = 222°C [1][2]. A Gibbs-adsorbed Bi monolayer resides at the surface in both regimes. However, a thick, Bi rich wetting film intrudes between the Bi monolayer and the Ga rich bulk at $T>T_{mono}$. How this structural surface transition at the surface is related to the bulk phase transition at T_{mono} remains an open question. In this period we have explored the surface structure of the GaBi liquid in a temperature range near T_{mono}.

Methods and Materials: The alloy with an overall Bi amount of 30 at% was contained in an UHV chamber. Surface sensitive x-ray reflectivity measurements were carried out using the liquid surface spectrometer at Beamline X22B. To avoid temperature gradients induced by the thermal radiation from the free surface a temperature-controlled radiation shield was installed above the sample.

Results: For temperatures far below T_{mono} only a Bi monolayer was observed, indicated by a broad peak centered around q_z=0.8Å^{-1} in the reflectivity, see Fig.1.[1] In Fig. 1 we also show data for T approaching T_{mono} for which the reflectivities exhibit peaks at low q indicative of a thick Bi-rich wetting film. As shown in Fig. 2 the thickness of this layer changes continuously on crossing T_{mono}.

Conclusions: The Bi-rich wetting film forms in a continuous way while approaching T_{mono} from below and vanishes in the same way on cooling, i.e. without hysterisis. The maximum value of the film thickness is determined by the equilibrium between the preference of the Bi-rich film by the surface field and the gravitational thinning of the film due to the fact that the film has a higher density than the competing Ga-rich subphase. The observed wetting behavior around T_{mono} is related to the bulk triple point transition and corresponds to the wet-non-wet scenario that has been discussed theoretically by Pandit and Fisher[3]. A similar behavior was previously found for GaPb by Chatain and Wynblatt with Auger Electron Spectroscopy;[4] however, this is the first time that one has obtained a detailed measure of the microscopic changes in the surface structure while approaching T_{mono}. By a quantitative analysis of the behavior at the wetting transition it should be possible to obtain a measure of the surface potential at the free surface.

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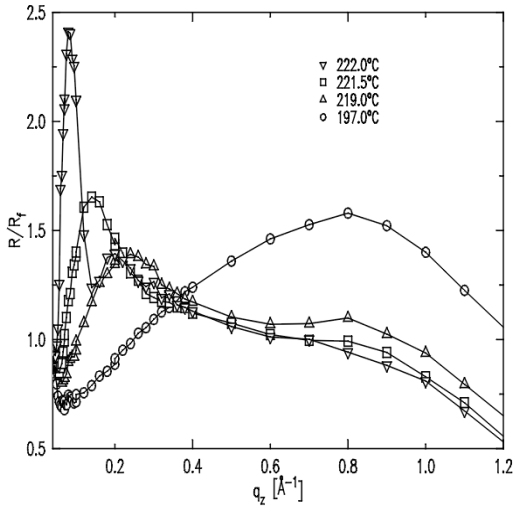

Figure 1. Fresnel-normalized x-ray reflectivities from the free surface of GaBi alloys for different temperatures.

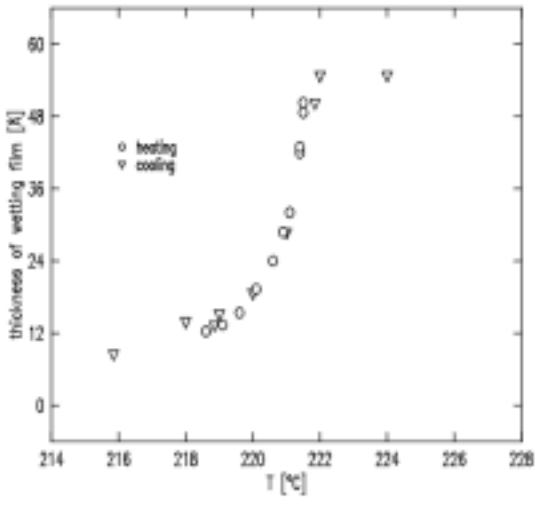

Figure 2. thickness of the Bi-rich wetting film versus temperature near T_{mono}=222°C.